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Agroforestry Tree Seed Production and Supply Systems in Malawi

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Abstract A sustainable agroforestry tree germplasm supply system is vital to resource-constrained smallholder farmers who depend on agroforestry to improve the productivity of their farm enterprises. Successful adoption of agroforestry hinges on the development of a sustainable agroforestry tree germplasm supply system. This paper reviews the agroforestry tree seed supply system in Malawi, with a view to determining its sustainability and quality. Currently, more than 90% of the documented agroforestry tree seed distributed to farmers is produced by smallholder farmers collected mainly from scattered farmland trees, the remainder being produced from seed orchards and seed stands owned or controlled by research organizations. Three organizations—namely the Land Resources Centre (LRC), National Tree Seed Centre (NTSC) of the Forestry Research Institute of Malawi (FRIM) and the World Agroforestry Centre (ICRAF)—were identified as major procurers of agroforestry tree seed produced by smallholder farmers. Agroforestry germplasm is distributed to farmers by non-governmental organizations (NGOs) and government agricultural and forestry extension departments. The procurement and distribution of germplasm to farmers is in general effective. The major challenge to sustainability of agroforestry tree germplasm distribution in Malawi is dependence on donor funding. The agroforestry tree seed system is, to some extent, sustainable with regards to production, although the genetic quality of the germplasm is low. Germplasm storage facilities at national level are available and possibly adequate, but knowledge and information on effective low-cost tree germplasm storage systems at household level are limited. Sustainability could be enhanced by strengthening of grass-root organizations involved in tree seed production to institutionalize

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the distribution through farmer–farmer exchange. There is also a need to support the development, promotion and adoption of low-cost tree germplasm storage facilities by smallholder farmers.

Keywords Agroforestry tree germplasm · Sustainability of supply · Seed storage · Farmland seed source

Introduction

One of the most important concerns in agroforestry scaling-up programs is the absence of sustainable tree germplasm supply (Aalbaek 2001; Ajayi et al. 2008) in the face of increasing demand for trees for soil fertility improvement, fruit, fuelwood, timber, fodder and ornamentals. Lack of reliable markets for agroforestry tree germplasm is a major impediment to the development of sustainable tree germplasm supply systems. For agricultural seeds, it has been pointed out that for many countries in sub-Saharan Africa, individual country markets on their own are too small for a competitive modern seed industry to develop (Gisselquist et al. 2005). This is also the case with agroforestry tree germplasm, for which the quantity required in any given country is not sufficiently large to stimulate large-scale investment by private companies. Furthermore, for large-scale seed companies, agroforestry tree germplasm, like non-hybrid seed of agricultural crops, may be unprofitable, due in part to: uncertainty and fluctuating demand largely driven by donor funded projects; competition from farm-saved seed; low seed multiplication rates (e.g. for *Gliricidia sepium*); lack of transportation and storage difficulties; and lack of strong regional and international markets.

In general, local level seed production systems in much of Africa fall in three categories: seed production using contract growers, seed exchange schemes, and farmer seed enterprises (David 2004). The advantages of farmer seed enterprises over other approaches include sustainability, decentralization of seed production to cater for local supply, and opportunities for linking to formal institutions (David 2004). Catacutan et al. (2008) documented an example of how organized smallholder tree seed producers in the Philippines achieved sustainable seed supply, increased market share and greater income. Their work showed that facilitating smallholder farmer collective action was important to gain market access, but was however, unlikely to sustain sales.

A sustainable agroforestry germplasm supply system is vital for the rapid development of agroforestry. Just as the sustainable supply of crop seeds is an important component to food security (Scowcroft and Polak Scowcroft 1999), the sustainable supply of agroforestry germplasm is a vital component of food security, more so for species used for soil improvement (fertilizer trees), fodder and fruit trees in smallholder farming systems. Scowcroft and Polak Scowcroft (1999) defined a sustainable crop seed supply system as one in which farmers have access to adequate high quality seed of the desired type (species and seed source) at the right time. The definition equally applies to agroforestry tree germplasm, with the

same critical features of availability, affordability and access to high quality germplasm on time.

Studying national agroforestry germplasm systems offers important insights into germplasm demand, farmers' sourcing strategies, management practices and species and seed source diversity required to design appropriate seed delivery strategies. Agroforestry tree germplasm support systems are also an important integral part of a sustainable germplasm supply system. Germplasm support systems generally relate to material inputs given to farmers, including seed, equipment, storage facilities, information, training and extension advice (Böhringer et al. 2003; Shisanya et al. 2007).

In this paper, the agroforestry tree seed production and supply system in Malawi is reviewed in relation to germplasm quality, availability and delivery, the key elements of sustainability. The review covers the major stakeholders in agroforestry tree germplasm production, storage and distribution. Agroforestry tree species in this paper are taken in the broadest sense, covering most of the tree species grown by smallholder farmers. These include trees intercropped with crops and trees planted for woodlots, live-fence or boundary markings, fodder, fruits, fuelwood and soil fertility improvement. The focus is on these species because they constitute between 67 and 100% of tree seeds produced or traded by major players in seed sales or distribution in Malawi (Pedersen and Chirwa 2005). Pines and eucalypts which are predominantly used in commercial forestry were excluded.

The Agroforestry Seed Sector in Malawi

The agroforestry seed sector in Malawi comprises a number of stakeholders (Pedersen and Chirwa 2005; Graudal and Lillesø 2007). These include the government national tree seed centre (NTSC) of the Forestry Research Institute of Malawi (FRIM), the Land Resources Centre (LRC), a quasi-government institution, the World Agroforestry Centre and more than a dozen local and international non-governmental organizations (NGOs), community-based organizations (CBOs) and individual farmers. The LRC was established following the transformation of a previously donor-funded project on scaling-up agroforestry. A simplified schematic representation of national actors and pathways of agroforestry seed in Malawi is provided in Fig. 1.

The agricultural seed system is usually split into two sectors, namely formal and informal (Scowcroft and Polak Scowcroft 1999). The formal seed sector is defined as a framework of institutions linked together by their involvement in the multiplication, processing and distribution of improved germplasm. The institutions in the formal seed system comprise regional, national and international agricultural research and policy organizations, private and public companies and business associations (Scowcroft and Polak Scowcroft 1999). Typically formal seed systems are characterized by a clear chain of activities, and regulations exist to maintain variety or germplasm identity and purity as well as to guarantee physical, physiological and sanitary quality. The informal seed sector consists of both individual farmers retaining seed from their harvest and farmers exchanging seed

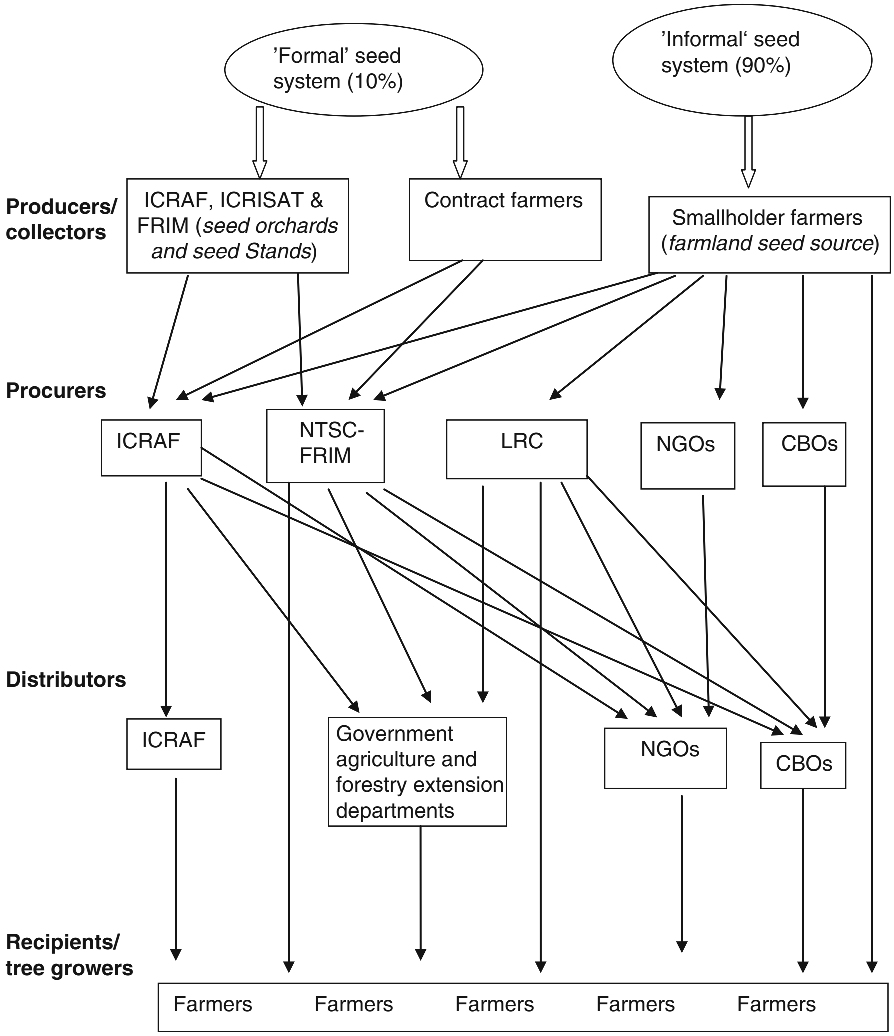

Fig. 1 Stakeholders and pathways of agroforestry tree germplasm in Malawi

with neighbors and relatives. There are usually no regulations to control the seed quality in the informal seed sector.

Agroforestry tree seed systems differ from agricultural seed systems in that there are no bred varieties per se for most trees and the attendant regulations exist only in developed countries; consequently, differences between formal and informal tree seed systems are largely blurred. In Malawi, agroforestry germplasm improvement is carried out by the World Agroforestry Centre, an international research organization, and by FRIM, a national institution under the Department of Forestry. Much of the agroforestry germplasm enhancement is centered on provenance selection and seed production. Seed production is usually from seed orchards, small

Table 1 Agroforestry tree seed orchards in Malawi by species and ownership as of 2010

Species	Owner	Genetic composition	Number of orchards	Orchard size (ha)
G. sepium	FRIM	Retalhuleu provenance	2	11.0
Gliricidia sepium	ICRAF	Bulk	9	7.1
G. sepium	FRIM	Plantation (provenance trial)	1	2.0
G. sepium	FRIM	Bulk	1	1.0
Tephrosia candida	ICRAF	Bulk	1	2.0
T. vogelii	ICRAF	Bulk	1	1.5
T. vogelii/T. candida	ICRAF	Bulk	1	2.0
Acacia angustissima	ICRAF	Bulk	1	0.5
Calliandra calothyrsus	ICRAF	Bulk	1	0.1
Leucaena pallida	FRIM	Bulk	1	0.6
L. pallida	ICRAF	Bulk	2	0.4
L. trichandra	ICRAF	Bulk	2	0.4

plantations (old provenance trials) and seed stands. The seed orchards were established with seed from either identifiable individual provenances or bulked seed (Table 1). Seed stands are selected on the basis of having trees with phenotypically superior and desirable characteristics and therefore seed collected from them is expected to be superior to unselected seed. Most seed of indigenous agroforestry trees (e.g. *Faidherbia albida*) is collected from seed stands in natural forests and woodlands. For agroforestry tree seed, this approximates to the formal seed system for agricultural crops. In the absence of government regulations on the production of agroforestry tree seed, the control of tree seed quality (genetic, physiological, physical and sanitary) in Malawi is largely a self-imposed system by ICRAF and FRIM.

What can be termed the 'informal' agroforestry tree seed sector in Malawi comprises mostly individual smallholder farmers and local communities, who collect tree seed from scattered trees (either planted or remnants of natural vegetation) on their farms for their own use and as a sideline activity, sell any excess to their needs to the local and national tree seed buyers. This particular type of tree germplasm is often called farmland sourced seed (Graudal and Lillesø 2007). For smallholder farmers, farmland is the most important seed source because of ease of access. Like the informal agricultural crop seed system, there are also no regulations governing the production of agroforestry tree seed from farmland seed sources.

Agroforestry Tree Seed Production in Malawi

Between 2007 and 2009, over 90% of the agroforestry tree seed procured and sold or distributed by FRIM, LRC and ICRAF, the three major agroforestry seed suppliers, was produced by smallholder farmers, harvested primarily from scattered trees planted on farmland or remnants of natural vegetation. Similar observations

were made by Pedersen and Chirwa (2005). The seed has no guarantee of the original provenance source (in the case of exotic tree species) and purity, a characteristic of the informal seed system. In agricultural crops, a comparable figure of between 80 and 90% of the seed used by smallholder farmers in Africa is also farmer-saved seed (Walker and Tripp 1998; Tripp 2001).

Less than 10% of the agroforestry germplasm sold or distributed to farmers in Malawi is harvested from seed orchards (Table 1), seed production areas, seed stands, plantations or woodlots. The germplasm in some of the seed orchards has genetic identity (i.e. provenance identity) while the rest of the seed orchards were established from bulked material collected from farmers' fields or from provenance trials (Table 1). In years of high agroforestry tree seed demand, it is not uncommon for organizations including ICRAF and ICRISAT to contract out seed production to both smallholder and large-scale farmers particularly for some agroforestry species, e.g. *Cajanus cajan* (Fig. 1).

Based on the mini-survey carried by ICRAF on agroforestry tree seed suppliers in 2009, the LRC was found to have a market share of more than 60% of the agroforestry tree seed supplied through the formal system. LRC was also found to source its entire agroforestry tree germplasm from smallholder farmers, while NTSC and ICRAF source 65 and 46%, respectively of their agroforestry tree seed from the farmers. Statistics on agroforestry tree seed production although sketchy appear to indicate that germplasm availability for most species is high, with the exception of *G. sepium*, *Acacia angustissima*, *Calliandra calothyrsus* and *Leucaena* spp which are often imported. Although *G. sepium* is a prolific flowerer in Malawi, pod development and seed set is very poor resulting in low seed yields.

Germplasm Procurement and Storage

Although agroforestry tree seed is largely produced by smallholder farmers, the procurement is undertaken predominantly by NTSC of FRIM, ICRAF and LRC, while the seed is distributed to farmers by ICRAF, NGOs and government departments of agriculture and forestry (Fig. 1). In 2007 for example, ICRAF and its development partners in Malawi began implementing a 4 years program of scaling up agroforestry called the Agroforestry Food Security Program (AFSP), operating in 11 districts. Agroforestry tree seed statistics for the 3 years (2007–2009) indicated that NGOs and donor-funded projects (including the AFSP) were the major buyers of germplasm from the three suppliers (LRC, NTSC and ICRAF), taking more than 89% of the germplasm. Only about 11% of the germplasm sourced from the three major suppliers was shared by the departments of Agricultural Extension (1.4%) and Forestry (0.4%) and by CBOs (4.3%) and individual farmers (4.6%).

Some NGOs and CBOs often carry out their own seed collection to supply seed to farmers directly as a way of cutting costs (Pedersen and Chirwa 2005). Records of such collections are not readily available. Farmer–farmer seed exchange of agroforestry may account for a small proportion of seed distribution because most farmers tend to favour being given seed by NGOs. Most NGOs who support farmers in agroforestry and tree planting often provide other nursery inputs including

nursery equipment, watering cans and fencing materials in addition to the tree seed. It is for this reason that some farmers would prefer to receive tree seed from the NGOs instead of exchanging among themselves.

Seed storage facilities are particularly critical because they enable farmers to take advantage of heavy seed years to build large tree seed stocks. There are two levels of seed storage that are important, namely storage at the individual household level and at the national level. All the three major germplasm procurers (ICRAF, LRC and NTSC) have storage facilities that include cold storerooms for long-term storage. The combined cold storage capacity for agroforestry tree seed in Malawi is in excess of 100 metric tonnes, with even more storage space at ambient temperature. Centralized storage capacity for agroforestry tree germplasm is therefore adequate.

The challenge of storing tree seed is widespread, and loss of seed to pests and diseases is common among resource-poor smallholder farmers in Malawi. Excess agroforestry tree seed is often not stored properly because of lack of knowledge on seed storage and absence of low cost storage facilities among smallholder farmers. To ensure that agroforestry tree seed does not deteriorate, excess seed once collected by farmers and not sold in the year of collection requires suitable storage structures to minimize seed loss. There is a need to develop and promote the use of low-cost germplasm storage facilities, e.g. locally made clay pots.

Species Diversity as Reflected by Available Germplasm

The promotion of tree species diversity in the various forms of agroforestry systems contributes to livelihoods of rural communities in the developing countries (Dawson et al. 2009). In Malawi, the diversity of species in any of the major germplasm suppliers' portfolios varies depending on the mandate or focus of the organization. Although Pedersen and Chirwa (2005) reported ICRAF's agroforestry tree germplasm portfolio as comprising <10 species, there is evidence that seed is collected from up to 30 species in some years. As a research organization, ICRAF only focuses on germplasm of tree species for which the organization has generated scientific information. The number of species for the NTSC is much wider because they cover all major tree uses: ornamental species, agroforestry, indigenous fruits and plantation species (Table 2). Despite this high species diversity, the tree seed centre is less driven by profit compared to LRC. The LRC focuses on those species that are in high demand because the centre is a profit-making organization. The LRC usually stocks tree seeds for between 10 and 20 species that are in high demand. Profit-driven organizations, by their nature, are less inclined to include germplasm of less marketable species.

Current Agroforestry Germplasm Distribution Systems in Malawi

In a survey on tree seeds in Malawi, Pedersen and Chirwa (2005) cited a number of NGOs involved in distribution of agroforestry seed to farmers. NGOs distribute most of the germplasm that they procure while the government agriculture and

Table 2 Agroforestry tree species available at major tree seed suppliers in Malawi

Species use	Tree seed supplier and species supplied			
	LRC	NTSC (FRIM)	ICRAF	Other institutions[a]
Fertilizer trees	*Sesbania esban, Tephrosiacandida, Tephrosia vogelii, Gliricidia sepium, Faidherbia lbida*	*G. sepium, S. sesban, T. vogelii, T. candida, Leucaena pallida, L. esculenta, L.trichandra, L. leucocephala, F. albida*	*Cajanus cajan, G. sepium, S. sesban, T. candida, T. vogelii, F. albida*	*C. cajan, T. candida, T. vogelii*
Fodder trees	None	None	*L. pallida, L. leucocephala, L. trichandra, L. esculenta, Acacia angustissima, Calliandra calothyrsus*	*L. pallida, L. leucocephala, L. trichandra, L. esculenta*
Indigenous fruits	*Ziziphus mauritiana*	*Z. mauritiana, Tamarindus indica, Adansonia digitata*	*Adansonia digitata, Z. mauritiana, Strychnos cocculoides, Vangueria infausta, Sclerocarya birrea*	None
Firewood trees species	*Senna spectabilis, Senna siamea, Acacia nigrescens, Acacia polyacantha, Albizia lebbeck, A. adianthifolia*	*A. nigrescens, A. nilotica, A. polyacantha, A. lebbeck, A. adianthifolia, Eucalyptus* spp., *S. spectabilis, S. siamea*	*A. lebbeck*	None
Indigenous timber tree species	*Afzelia quanzensis, Khaya anthotheca*	*A. quanzensis, K. anthotheca, Pterocarpus angolensis, Dalbegia melanoxylon*	None	None
Medicinal	*Melia azedarach, Moringa oleifera*	*Azadirachta indica, M. azedarach, M. oleifera*	None	None
Shade and ornamental	*Toona ciliata*	*Jacaranda mimosifolia, T. ciliata*	None	None
Plantation forestry	None	*Pinus* spp., *Eucalyptus* spp.	None	None

Table 2 continued

Species use	Tree seed supplier and species supplied			
	LRC	NTSC (FRIM)	ICRAF	Other institutions[a]
Conservation	None	*Widdringtonia cupressoides*	None	None
Others species	*Piliostigma thonningii*, *Terminalia sericea*	*Burkea africana*, *Combretum imberbe*, *Colophospermum mopane*, *Denolix regia*, *T. sericea*	None	None
Number of species in stock	10–20	>50	<20	<10

[a] These institutions include Bunda College, Mzuzu University and ICRISAT

forestry extension departments occasionally distribute agroforestry tree germplasm to farmers when they partner with NGOs and donors. For example in the Irish Aid funded Agroforestry Food Security Programme (AFSP), the agriculture and forestry extension departments partnered ICRAF in the distribution of the tree germplasm. The NGOs that have been actively involved in agroforestry germplasm distribution include: Co-ordination Unit for the Rehabilitation of the Environment (CURE), Malawi Environmental Endowment Trust (MEET), Churches Action for Relief and Development (CARD), Greenline Movement, World Vision International (WVI), Total Land Care (TLC), Evangelical Lutheran Development Programme/Lutheran World Federation (ELDP/LWF), Border Zone Project, Concern Universal, Concern Worldwide, The Wildlife and Environmental Society of Malawi (WESM), Rural Foundation for Afforestation (RUFA) and Action Aid (Pedersen and Chirwa 2005).

A mini-survey carried out by ICRAF in 2009 covering the three major agroforestry germplasm buyers in Malawi (LRC, NTSC and ICRAF) revealed that the quantity of agroforestry tree seed (excluding pines and eucalypts) bought for distribution annually was about 50 metric tonnes over the 2007–2009 period. Nearly half of this germplasm (an average of 21 metric tonnes per annum) was distributed to farmers participating in the AFSP (Table 3). More than three quarters of the germplasm distributed by the AFSP was for fertiliser tree species (*G. sepium, T. candida, T. vogelii, S. sesban, F. albida* and *C. cajan*), which was consistent with

Table 3 Agroforestry tree germplasm distributed to farmers over 3 years in Malawi under the agroforestry food security programme

Species	Year and germplasm quantity (kg)			
	2007	2008	2009	Total
Tephrosia vogelli	8,105	4,478	4,810	17,393
Tephrosia candida	4,930	5,373	3,844	14,147
Cajanus cajan	5,540	4,851	2,000	12,391
Faidherbia albida	948	3,009	2,410	6,367
Sesbania sesban	1,100	1,532	1,118	3,750
Gliricidia sepium	857	1,304	571	2,732
Albizia adianthifolia	46	175	1,563	1,784
Acacia polyacantha	489	279	647	1,415
Albizia lebbeck	580	317	11	908
Leucaena pallida	136	152	375	664
Leucaena trichandra	235	277	73	584
Khaya anthotheca	176	141	0	317
Calliandra calothyrsus	126	132	49	308
Senna siamea	159	117	17	292
Senna spectabilis	122	104	0	226
Leucaena esculenta	56	58	1	115
Acacia angustissima	63	40	0	104
Total	23,668	22,339	17,489	63,497

the project objective of improving food security through improved soil fertility. The figure excludes more than 50 metric tonnes of germplasm of fruit trees (mango, avocado and peach stones and lemon seed) that was also distributed for raising rootstock (AFSP 2007, 2008, 2009).

The packaging of agroforestry tree seed in small seed packets proved to be highly effective for distributing seed to a large number of target beneficiaries. In the AFSP program, seed was distributed to individual farmers in small packets, each packet containing enough to establish a 0.1 ha plot in the case of direct sown fertilizer trees (tephrosia, pigeon pea). For nursery raised tree species, seed was distributed to both individual and group nurseries. By the end of the third year of AFSP implementation, agroforestry germplasm had been distributed to nearly 180,000 smallholder farmers (AFSP 2009). The approach included packaging seed in small sachets, labeled with nursery and management instructions in local languages, and then distributing through the network of the government extension departments, farmers' organizations and NGOs.

Quality of Agroforestry Tree Germplasm in Malawi

Concerns about the low quality of agroforestry tree germplasm have been raised in Malawi (e.g. Pedersen and Chirwa 2005; Graudal and Lillesø 2007), and elsewhere (Brandi et al. 2007; Catacutan et al. 2008). It has, however, been observed that most stakeholders do not know the broader meaning of germplasm quality (Pedersen and Chirwa 2005; Graudal and Lillesø 2007; Brandi et al. 2007). In Uganda, most organizations supplying agroforestry germplasm were reported to be less informed on what constitute genetic quality because this was considered to be synonymous with germination percentage (Brandi et al. 2007). The report concluded that any seed of high genetic quality that was given to farmers in the surveyed area in Uganda was only by chance and not because of a deliberate effort by the NGOs. In Malawi, it was also noted that agroforestry germplasm was being sourced and distributed without any documentation on its genetic, physiological and physical quality. Even the most basic information on seed quality such as viability is often not provided (Lillesø 2007). Although guidelines for collecting seed of high genetic quality from natural forests or seed stands recommend a minimum of 30 trees with a minimum distance of 50 m (Dawson and Were 1997), many smallholder farmers in Malawi collect from no more than 5 trees (Mvula and Lillesø 2007; Namoto and Likoswe 2007). Mvula and Lillesø (2007) attributed the collection of germplasm from far less than the recommended number of trees to economic factors. Other causes may be the scarcity of mother trees in some localities or the fact that extension guidelines for tree germplasm collection are not reaching farmers.

There is a need to promote germplasm exchange among farmers. According to Lewis and Mulvany (1997), on-farm saved seed is of known quality to the farmer while exchanged germplasm with neighbors has 'neighbour or community certification' and is therefore likely to be of high quality. Since individual farmers were observed to collect seed from a few trees (Namoto and Likoswe 2007), seed exchange among the farmers if promoted could provide the desired number of

mother trees as recommended by Dawson and Were (1997). With the establishment of community tree seed banks, individual farmers' collections will be bulked thus increasing the number of trees contributing germplasm.

With the exception of a few seed orchards that were established with seed of known provenances, most seed orchards in Malawi were planted with material from either unknown sources or bulked (Table 1). Although some of the seed orchards were well isolated to minimize contamination, there may not be any benefits that will be realized from those seed orchards that were planted with germplasm of unknown sources. The germplasm collected from some of the seed orchards may not therefore be of high quality unless the orchards were isolated and contained proven material. This is an area where future seed orchard development by institutions needs to focus on.

In view of these challenges regarding the production of high quality agroforestry tree germplasm, participants in an agroforestry tree seed stakeholders' workshop held in Malawi proposed the following resolutions (Lillesø 2007):

- seed production guidelines for all key agroforestry species should be developed and adopted for use by all players in the seed production and collection business;
- agroforestry tree seed must be certified;
- agroforestry tree seed testing for physical and physiological quality needs to be made mandatory;
- agroforestry tree seed distributed should be labelled with basic information on quality characteristics including viability, purity and seed source;
- an institution with experience in tree seeds (e.g. FRIM) must be mandated to enforce quality control of agroforestry germplasm sold or distributed to farmers.

Despite these proposals, the control of germplasm quality of agroforestry tree species has not been implemented in Malawi. As a start, the control of tree germplasm quality could perhaps be implemented in phases, commencing with one of the easiest and most understood parameter of seed quality such as viability and building up by progressively adding genetic, sanitary and other quality attributes. Institutions that establish seed orchards must be encouraged to establish orchards with material of known genetic potential. There are no advantages of isolating seed orchards established with material of unknown source and productive potential.

Sustainability of the Agroforestry Tree Seed System

Unlike the distribution of agroforestry tree seed which is largely aided by donors, the production of agroforestry seed is mostly undertaken by smallholder farmers, which in a way makes the process sustainable even in the absence of donor support. The issue, however, may be different from the quality perspective. More needs to be done to improve the genetic, physical, physiological and sanitary quality of the agroforestry tree germplasm to optimize productivity of agroforestry systems. The storage of excess agroforestry tree germplasm remains a challenge among smallholder farmers because most farmers do not use any chemicals to protect the seed. Also information on appropriate storage facilities is limited. The use of

low-cost storage facilities such as earthen pots, used plastic containers, and tins should be explored and promoted.

The current system of delivery of germplasm although highly effective may be considered unsustainable because a considerable amount of seed distributed by NGOs and government departments relies on donor support. However, one may infer that in the long term, as more farmers establish their own trees, and are trained in seed production and storage, they will have their own supply of seed, thereby making the system more sustainable. The current improved tree seed availability in Malawi can be attributable to the efforts during the last 10 years of agroforestry scaling-up which involved seed provision to smallholder farmers. The trees established from past scaling-up work are currently the sources of agroforestry tree seed.

A program focusing specifically on Community Agroforestry Tree Seed (CATS) banks was initiated by ICRAF in 2009 in three districts of Malawi (Fig. 2). CATS banks, as the name implies, are community-based tree seed banks that are owned and run by the communities themselves for the purpose of producing tree seed for their members and for sale (Akinnifesi 2008). The aim of the CATS bank program is to establish a sustainable production and supply system of high quality agroforestry tree germplasm at community level. The approach is similar to the farmer seed enterprises (FSEs) for agricultural seeds described by David (2004). In the first phase of the CATS Bank project, ICRAF will manage the agroforestry seed

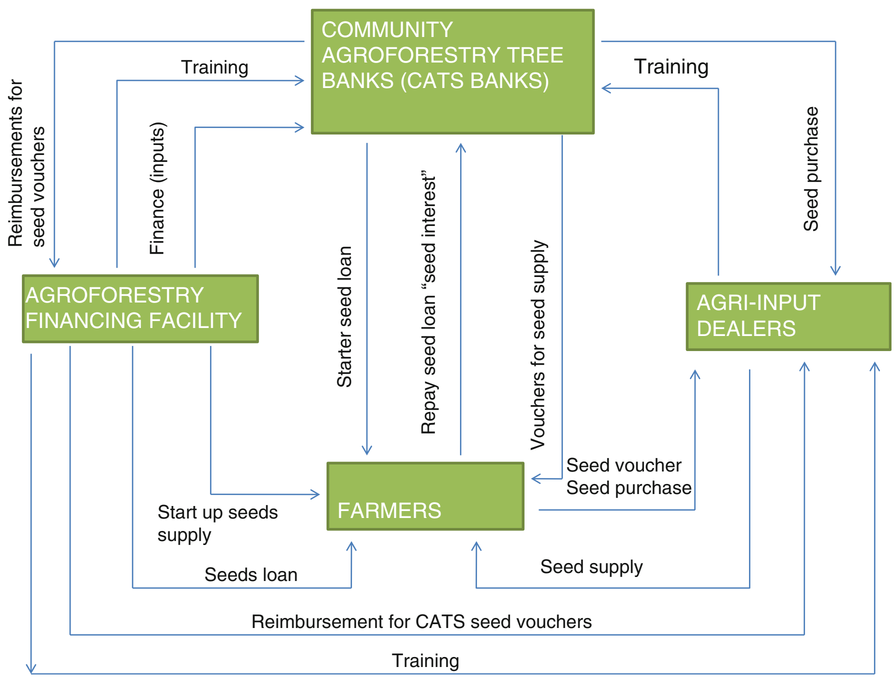

Fig. 2 Conceptual framework of the community agroforestry tree seed bank (CATS Bank) approach. *Source* Akinnifesi (2008)

financing facility (AFSFF) which will provide seed loans to participating farmers (Fig. 2). ICRAF will also provide start up services including training and financing of the operations of CATS Bank groups and linking them to agri-seed dealers such LRC and NTSC (Akinnifesi 2008). Once the CATS banks become functional, the role of ICRAF will gradually be transferred to the CATS banks themselves and agri-dealers.

On germplasm accessibility, another component of a seed supply system, the situation in Malawi can be described as mixed in the sense that although there is ready access to germplasm per se (Namoto and Likoswe 2007), high genetic quality is scarce. Namoto and Likoswe (2007) found that most farmers collect seed from <5 trees, which is far fewer than 30 trees recommended by Dawson and Were (1997). The focus of germplasm supply must therefore combine sustainability and high quality so that farmers have reliable access to highly productive germplasm.

There is perhaps a need to take advantage of the current system of the production of agroforestry tree seed by smallholder farmers, by further facilitating the establishment of sustainable community tree seed distribution pathways. Village Natural Resources Management Committees (VNRMC) and CBOs are some of the potential distribution pathways that could be used. There is also a need to capacitate farmers to establish storage facilities for tree seed germplasm.

The failure of establishing successful sustainable tree seed supply systems in Malawi is perhaps a result of the approach of appending agroforestry tree germplasm supply programs to other agroforestry development programs resulting in the former being crowded out. Also, donor funded agroforestry development programs are usually implemented over a period of <5 years, which may be too short to establish and operationalize a germplasm supply system for tree crops, which take several years to flower and seed. Agroforestry tree seed production takes a minimum of 3 years for precocious tree species, by which time most traditional development programs will be half way through or winding up. There is also a need for government and the development partners to develop and implement seed supply systems as separate entities rather than bunch them together with other programs that may have short implementation periods.

Conclusions

The agroforestry germplasm supply system in Malawi has both sustainable and unsustainable components. The production of agroforestry tree germplasm is largely controlled by smallholder farmers, a potentially healthy scenario in terms of sustainability, but has shortcomings, particularly with regards to the genetic quality of germplasm. There is a need to train agroforestry extension personnel and farmers on issues of germplasm quality, which appear to be poorly understood. The germplasm distribution system although highly effective is to some extent unsustainable because it is largely aided by NGOs and government agriculture and forestry extension departments. Opportunities exist to promote the establishment of community tree seed banks and tree germplasm exchange among farmers. Although tree germplasm storage facilities at national level are adequate, storage

facilities at household and community level appear to be inadequate. There is a need to test and promote effective low-cost storage facilities including earthen pots at household and community level for storage of tree germplasm. Other than for *G. sepium*, which inherently has low seed yield, Malawi is potentially self-sufficient in agroforestry tree germplasm.

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